Table 24
Lakes Fully Supporting Uses

Size		
5000 Acres or Larger	Less than 5000 Acres	
Barkley	A.J. Jolly	Linville
Barren	Arrowhead	Long Pond
Cave Run	Beaver	Long Run
Cumberland	Bert Combs	Luzerne
Dale Hollow	Beshear	Malone
Green	Blythe	Mauzy
Kentucky	Boltz	Metropolis
Laurel River (except for headwaters)	Buck	Mill Creek (Monroe Co.)
Nolin	Bullock Pen	Mill Creek (Powell Co.)
	Burnt Pond	Moffit
	Campton	Paintsville
	Cannon Creek	Pan Bowl
	Carnico	Peewee
	Chenoa	Pennyrile
	Corinth	Providence City
	Doe Run	Scenic
	Elmer Davis	Shanty Hollow
	Energy	Smokey Valley
	Fish	Spurlington
	Fish Pond	Swan Pond
	Flat	Turner
	Freeman	Tyner
	General Butler	Washburn
	George	Willisburg
	Grapevine	Wood Creek
	Grayson	
	Greenbo	
	Greenbriar	
	Hematite	

Table 25
Threatened Lakes

Lake	Use* Threatened	Cause	Source
Kentucky	SCR	Macrophyte infestations	Natural or introduced exotic species
	WAH	Low dissolved oxygen	Unspecified nonpoint sources
Paintsville	WAH	Salinity/brine	Petroleum activities
Barkley	SCR	Suspended solids	Unspecified nonpoint sources

*SCR - Secondary Contact Recreation, WAH - Warmwater Aquatic Habitat

Table 26

Causes of Use Nonsupport* In Lakes

Cause	Number of Lakes Affected	Acres	% Contribution (by Acres)
Nutrients	24	8,748	46
Metals (Fe/Mn)	3	5,314	28
Suspended solids	5	4,517	24
Other (Shallow lake basin)	4	236	1
pH	1	219	1
Other inorganics (noncarbonate hardness)	1	135	< 1

*Nonsupport is a collective term for lakes either not supporting or partially supporting uses

Table 27

Sources of Use Nonsupport* in Lakes

Source	Major Impact (Acres)	Moderate/Minor Impact (Acres)
Point Sources		
Municipal	6,041	455
Nonpoint Sources		
Agriculture	8,182	
Resource Extraction	4,862	
Septic tanks	169	
Other		
Lake fertilization	252	
Natural	5,814	

*Nonsupport is a collective term for lakes either not supporting or partially supporting uses

percentage of lake uses not being supported (51%). Municipal point sources were responsible for 25 percent of the use nonsupport, followed by natural causes which accounted for 23 percent of use nonsupport.

More detailed studies in watersheds of the lakes in the agriculture category are necessary before contributing sources of nonpoint pollution can be distinguished. Surface mining for coal (resource extraction) is the next greatest contributor to lake uses not being fully supported. Lake recreational uses are impaired because waters become turbid after receiving runoff water laden with sediment from lands disturbed by surface mining activities. This reduces the incentive for secondary contact uses.

Water Quality Trend Assessment

Trophic Trends

One of the objectives of the ambient monitoring program is to assess eutrophication of Kentucky lakes. The monitoring strategy is to obtain at least two years of data during the growing season on each lake. After the data is assessed, a decision is made either to continue monitoring or to assess another lake.

A review of current lake data from the ambient monitoring program, data retrieved through STORET on COE managed lakes, data from the lake assessment program, and other reports resulted in an assessment of trophic trends at several lakes. As mentioned earlier, a change in the chlorophyll TSI value (averaged over the April - October growing season) of 10 units was used to indicate a trophic change. A discussion of trends from the above databases follows.

Lakes in the Assessment Program. TSI values were compared for those lakes assessed in 1981-1983 which had been resurveyed in 1989. Comparisons of two data sets does not provide a strong trend analysis because the intervening years were not sampled. They do, however, indicate a change. The comparisons, as noted in Table 13, showed that Spurlington, Campbellsville City, Jericho, Doe Run, and Wood Creek lakes were more eutrophic. Lake Jericho's change resulted in its warmwater aquatic habitat use not being supported. Wood Creek Lake changed from an oligotrophic to a mesotrophic state. No uses were impaired. Honker Lake changed from a eutrophic to a mesotrophic state.

Lakes in the Ambient Monitoring Program. The following is a discussion on individual lakes which have been monitored over several years by the Division of Water, the COE, and other researchers. Analyses are based on the combined databases. Trophic trends are indicated by a change in TSI values of 10 units or greater. The extent of these databases gives the trend assessments a high level of confidence.

Green River Lake. COE data from 1981 indicated that this lake might be changing from a mesotrophic to a eutrophic state. Subsequent sampling in 1985 and 1986 by the DOW showed the main body of the lake to be mesotrophic. The 1989 COE data indicated that the lake was eutrophic. The TSI value changed from 44 (mesotrophic) to 55 (eutrophic). Monitoring by the COE will indicate if this eutrophic trend continues.

Nolin River Lake. The 1988 305(b) Report indicated that this lake was changing from a mesotrophic to a eutrophic state. The period of record showed the lake to be mesotrophic from 1975 through 1983 (TSI average was 44). Data from 1982 through 1987 showed an eutrophic trend. The TSI value was 55 in 1987. The DOW last monitored the lake in 1988 and verified that the lake was eutrophic (TSI was 52).

Carr Fork. This lake has historically been oligotrophic. TSI values before 1981 averaged 37. A lake fertilization program conducted by the Kentucky Department of Fish and Wildlife Resources to increase fishery potential caused the lake to become eutrophic from 1981 through 1985. A decrease in fertilization dosages resulted in a change to a mesotrophic state in 1986. Data from 1988 and 1989 revealed that the lake was once again eutrophic (average TSI was 53).

Reformatory Lake The Division of Water classified this lake as hypereutrophic in the 1984 305(b) Report. Its use as a recreational fishing resource was impaired because of severe hypolimnetic oxygen depletion and low dissolved oxygen in the epilimnion. Nutrients from livestock operations in the watershed were suspected of being the major cause of the lake's trophic state.

In order to alleviate what had become a potentially serious eutrophication problem, Division of Water staff met with the managers of the livestock operations and, with assistance from staff of the University of Kentucky's Agriculture Extension Service, suggested that better waste handling practices be instituted. The managers were cooperative, and steps were taken to handle the livestock waste in several of the suggested ways.

The Division began monitoring the lake in 1985 to determine if lake water quality had improved after the implementation of these better management practices. Preliminary data from 1985 indicated that the measures taken by the farm managers had dramatically improved lake water quality. Average spring through fall data showed that in the surface waters, there was 77 percent less chlorophyll *a* in 1985 than in 1981. This resulted in greater water clarity (the Secchi depth doubled) and a doubling of the depth of the euphotic zone. There was 78 percent less total phosphorus and a 59 percent decrease in total nitrogen. Dissolved oxygen remained above 5 mg/l in the upper water column in 1985, in contrast to 1981 when the concentration in the surface water declined to 2.4 mg/l. Hypolimnetic oxygen depletion occurred at a lower rate in 1985, and concentrations did not decline below 1.0 mg/l as they had in 1981. The lake was no longer considered hypereutrophic, based on an average TSI value decline of 15 points from 72 to 57.

The lake was monitored in 1986 and 1987 to verify that the improvements were sustained. It appeared that this had not occurred. The 1987 data showed that chlorophyll *a* had increased to near 1981 concentrations, water clarity had declined, and euphotic zone depths were back to 1981 values. Dissolved oxygen was again below 5 mg/l in the epilimnion and there was severe hypolimnetic oxygen depletion. The lake was hypereutrophic in the summer and fall. It was placed on the list of lakes that did not support their uses in the 1988 305(b) Report. Monitoring of the lake continued in 1988 and 1989. That data indicated conditions had changed and caused water quality to worsen. Total phosphorus averaged 117 ug/l in the spring through fall period in 1989 which is more than twice the value found in 1986. The TSI value was 77 compared to 53. The lake had shifted from an eutrophic to a hypereutrophic state. A recent farm site visit indicated no drastic changes in management practices. Causes of the deterioration in water quality are presently being investigated.

McNeely Lake. This lake no longer has problems from excessive duckweed growth, because grass carp introduction has effectively eliminated the duckweed. The lake is, however, still eutrophic, has severe epilimnetic and hypolimnetic oxygen depletion, and has reported fish kills. It is still considered as not supporting a warmwater aquatic habitat use. The discharges from package treatment plants in the watershed were piped to the stream below the lake outlet structure in December of 1988. This has caused a noticeable improvement in water quality and should eventually restore the warmwater aquatic habitat use. Phosphorus concentrations have declined. The average TSI in 1989 was 65 (eutrophic), which was a decrease of 9 units from the 74 (hypereutrophic) value in 1988.

Other Trends in Water Quality

Cave Run Lake. This lake was previously listed as threatened by brine pollution from petroleum activities (oil well operations) in its watershed. Chloride levels monitored by the COE indicated a steady increase in concentration beginning before 1981. Water column data at the dam for the years 1974-1976 showed a mean chloride concentration of 4 mg/l. In 1981 the mean was 10 mg/l, in 1983 it was 13 mg/l and by 1986 it was 22 mg/l (four and one-half times greater than the 1974-1976 levels). Chloride data from the Licking River, the main inflow to the lake, showed a similar trend but with much higher concentrations. The average chloride concentration from 1972 to 1976 was 9 mg/l. In 1981 it was 23 mg/l and in 1983 it was 57 mg/l. The concentration peaked in 1985 with an average of 200 mg/l. The 1986 average concentration declined slightly to 158 mg/l. The 1985 average was 21 times greater than the 1972 - 1976 levels.

COE data from 1987 showed a decline at the dam station to 13 mg/l which was coupled with a Licking River decline to 42 ug/l. Too few measurements were reported in 1988 and 1989 to indicate further trends. The lake has been removed from the threatened list of lakes as a result of the 1987 data assessment. It is hoped that the COE will provide continued monitoring for chlorides to indicate further water quality changes in the lake.

Cranks Creek Lake. Serious declines in pH in this lake were reported by the Kentucky Department of Fish and Wildlife Resources (KDFWR) in 1988. The source was determined to be periodic acid mine drainage. Declines in pH followed periods of low flow in tributary streams when available dilution was low and acid mine discharges became the major source of flow. An organization called "Living Lakes" has undertaken restoration of the lake in cooperation with the KDFWR. They are liming the lake at scheduled times to neutralize the acid impacts. The DOW has been contacted and approved the restoration efforts. A cooperative effort between DOW and KDFWR is planned to address the feasibility of eliminating the acid mine drainage problem.

Dale Hollow Reservoir. Tributary streams to Dale Hollow Reservoir were monitored for the COE in 1985 by Dr. John Gordon of Tennessee Technological University. The objective of the monitoring was to identify any problem areas which might threaten the high levels of water quality in the lake. Results of the monitoring effort indicated that at least three streams on the Kentucky side of the lake had water quality problems relating to brines from oil and gas production areas. The DOW monitored the embayments that these creeks flowed into (along with three other embayments on the Kentucky side) in 1987 and 1988. The objective was to determine if these embayments were being impacted by stream inputs. Measurements were made for chlorides and sulfates to determine if oil field pollutants were changing water quality. Chlorophyll a and nutrient measurements were also taken to assess the trophic state of the embayments. Results showed minimal increases in chloride concentrations in the Illwill Creek and Little Sulphur Creek embayments, when compared to control embayments. These were the embayments linked to streams flowing through oil production areas. Increases in chloride concentrations were 2 to 3 mg/l above controls. The embayment of Spring Creek had an increase of 10 to 13 mg/l chloride over controls. It was also eutrophic while the other embayments were mesotrophic or oligotrophic. The eutrophic state and higher chloride concentration are attributed to the discharge of municipal wastes to Spring Creek, from the City of Albany. Embayment recreational and aquatic life uses were, however, fully supported.

CHAPTER 3

WATER QUALITY ASSESSMENT OF GROUNDWATER

WATER QUALITY ASSESSMENT OF GROUNDWATER

Public concern for groundwater has increased nationwide and Kentucky is no exception. Currently, information on the state's groundwater resource is lacking and this can prove detrimental to protection and allocation efforts. The lack of data hampers Kentucky's groundwater protection goal, which is to maintain and protect the resource for its highest and best use and to minimize or prevent degradation.

Ambient groundwater quality has been determined in some local areas through special projects and cooperative efforts, but groundwater quality for the majority of the state remains unknown. Groundwater quantity and availability also remain largely unaddressed. There is an immediate need in Kentucky for a comprehensive aquifer mapping and groundwater classification program. Resource limitations have prevented concentrated effort on such a program, but the Division of Water is directing its efforts toward such a program. Assistance from other agencies, including the Kentucky Geological Survey, and the United States Geological Survey will be needed in order to implement a comprehensive mapping and classification program.

The protection of groundwater in the Commonwealth of Kentucky presents unique problems not encountered by many states. The hydrogeologic characteristics of karst areas must be determined on a case-by-case basis. Additionally, the majority of the federal technical assistance and guidance is not applicable to karst areas.

Sources and Contaminants in Groundwater

Table 28 presents the major sources of groundwater contamination in the state and ranks the top five sources (number one being the most serious). Table 29 lists those substances contaminating groundwater in the Commonwealth from the sources listed in Table 28.

Proposed Environmental Indicators

In this report, Kentucky has attempted to assemble the data necessary to respond to a set of environmental indicators proposed by the U.S. Environmental Protection Agency (EPA) in their 305(b) guidance document. In doing so, gaps and/or inconsistencies in the data necessary to fully address or respond to some of the proposed indicators have been identified. For other indicators, Kentucky's programs are not yet to the point where the requested data can be collected.

Tables 30 and 31 utilize suggested indicators from groundwater-supported public water supplies. Table 30 contains the number of groundwater-supported public water supplies with Maximum Contaminant Level (MCL) violations. These violations represent contaminants detected in the finished water and may or may not be indicative of groundwater quality. Table 31 contains the groundwater-supported public water supplies that had volatile organic compounds detected during at least one quarterly sampling event. This data is representative of groundwater quality problems, but as yet cannot be used to indicate a trend in groundwater quality because each water supply is only included in the quarterly sampling program for one year. In other words, this data only indicates contamination. 1988 data cannot be compared to 1990 data to indicate trends. Additionally, this table only contains data for regulated volatile organic compounds and does not consider unregulated organic compounds.

Table 28
Major Sources of Groundwater Contamination

Source	Relative Priority
Septic tanks	2
Municipal landfills	
On-site industrial landfills (excluding pits, lagoons, surface impoundments)	
Other landfills	
Surface impoundments (excluding oil and gas brine pits)	
Oil and gas brine pits	5
Underground storage tanks	1
Injection wells (inc. Class V)	
Abandoned hazardous waste sites	3
Regulated hazardous waste sites	
Salt water intrusion	
Land application/treatment	
Agricultural activities	
Road salting	
Improper well construction	4

Table 29
Substances Contaminating Groundwater

Organic chemicals:		Metals	X
Volatile	X*	Radioactive material	X
Synthetic	X	Pesticides	X
		Other agricultural chemicals	X
		Petroleum products	X
		Other (bacteria)	X
Inorganic chemicals:			
Nitrates	X		
Fluorides			
Arsenic	X		
Brine/salinity	X		

*Substances present

The Comprehensive Environmental Response, Compensation and Liability Act (Superfund or CERCLA) waste disposal sites present two problems for use in groundwater quality assessment. First, the National Priority List (NPL) sites are only a small subset of sites with contamination. In Kentucky, 500 plus sites are on the CERCLA list, yet only 250 have had a preliminary assessment/site investigation. Additionally, 65 sites have confirmed hazardous waste or contamination on site but do not score high enough to be placed on the National Priority List (NPL). The second major issue is the lack of complete information at the state level. The Superfund program is not delegated to states. EPA manages the Superfund program and maintains the official files and information on each NPL site. Of the 17 NPL sites in Kentucky, three sites have groundwater contamination but Kentucky has not been furnished the data. Four of the NPL sites have had no sampling and on three sites Kentucky has no information. The information requested is not available at the state level so this indicator could not be utilized.

The guidance also suggested the use of Resource Conservation and Recovery Act (RCRA) hazardous waste disposal site information for assessment of groundwater quality trends. Kentucky would suggest that all RCRA facilities be included in the water quality assessment report. Storage facilities have contaminated groundwater as a result of spills or solid waste management units. As more RCRA facilities perform RCRA Facility Assessments and RCRA Facility Investigations, more accurate information on groundwater impacts will be available. The categories of contaminants should indicate which RCRA waste would be included in each category. Tables 32 and 33 compile available information in the format requested in the federal guidance. Interpretation of the tables is limited by the lack of off-site information indicating groundwater contamination from these sites. The tables are provided to indicate known contaminants from RCRA sites in Kentucky.

Table 30
Number of Groundwater Supported Public Water Supplies (PWS) with MCL* Violations

MCL Parameter	No. PWS with MCL Violations 1988	1989
Turbidity	1	5
Barium	1	0
Fluoride	3	3
Nitrate	1	0
Selenium	0	0
Trihalomethanes	0	0
Bacteria	25	33

*MCL = Maximum Contaminant Level

Table 31
Groundwater Supported Public Water Supplies (PWS) with Volatile Organic Chemical Contamination

Volatile Organic Compound	Number of PWS with Contaminant Detected during at least 1 Quarterly Sampling	Concentration (micrograms/liter)			
		Min. Value	Max. Value	Avg. Value	MCL Value
1989					
1,4-dichlorobenzene	10	0.001	0.011	0.003	0.075
1,1,1-trichloroethane	6	0.001	0.083	0.019	0.002
1,2-dichloroethylene	1	0.002	0.003	0.002	0.007
Carbon Tetrachloride	1	0.003	0.003	0.003	0.005
Vinyl Chloride	1	0.010	0.010	0.010	0.002
1988					
1,4-dichlorobenzene	5	0.001	0.003	0.002	0.075
1,1,1-trichloroethane	2	0.001	0.019	0.008	0.200
Trichloroethylene	2	0.001	0.003	0.002	0.005
Carbon Tetrachloride	2	0.001	0.014	0.008	0.005

Table 32
RCRA Hazardous Waste Site Groundwater Contaminants
(1989)

Contaminant	Total Wells (On-Site)	Concentration Level Status[1] 0	1	2	3	Total Wells (Off-Site)	Concentration Level Status[1] 0	1	2	3
Polychlorinated biphenyls	7		5		2	1				1
Pesticides	5		5							
Other organics	24		4	6	13	5			1	4
Metals	23	1	7	13	6	2			1	1
Bacteria	2		2							
TOC. TOX.*	3									
Cyanide	1			2						
Radioactivity	2			6			6			

1. Concentration Level Status 0 = unknown, 1 = at or below detection limit, 2 = above detection limit, 3 = above level of concern (above MCL if MCL exists)
*TOC. = Total organic carbon
TOX. = Total organic halogens

Table 33
RCRA Subtitle D Waste Disposal Site
(Landfills) Groundwater Contaminants
(1989)

Contaminant	Total Wells (On-Site)	Concentration Level Status[1] 0	1	2	3
Polychlorinated biphenyls	NA	-			
Pesticides	0	-			
Other organics	6	-		5	1
Metals	31	-		21	10
Conventional	32	-		32	
Bacteria	7	-	5	2	

[1]Concentration Level Status 0 = unknown, 1 = at or below detection limit, 2 = above detection limit, 3 = above level of concern (above MCL if MCL exists)

"Conventional contaminants" was not defined in the guidance. Therefore, Kentucky used this category to represent secondary drinking water quality standards. A few wells have been sampled off-site at landfills; however, this information has not been compiled. Of the 187 landfills permitted in Kentucky, 59 solid waste sites submit groundwater analyses to the Division of Waste Management. Only 15 of these are required to submit organic analysis. These data represent information collected over more than one year.

Special Studies

DRASTIC Model Evaluation

The Institute for Mining and Minerals Research, University of Kentucky, conducted a study to evaluate the suitability of the DRASTIC Method for assessing the vulnerability of groundwater to contamination. The DRASTIC Method uses depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone, and hydraulic conductivity of the aquifer to determine the vulnerability of groundwater to surface contamination.

The study was designed to evaluate the applicability of the DRASTIC Method in Kentucky; evaluate information existing on the Kentucky Natural Resources Information System (KNRIS); and evaluate and estimate the cost of a statewide DRASTIC mapping program.

Kentucky is faced with the problem of addressing groundwater protection in karst areas. An objective of this study was to assess the applicability of DRASTIC in karst areas. Many of the parameters used in the DRASTIC method are not representative of the real world mechanisms which contribute to the vulnerability of a karst aquifer to contamination. For instance, the method assigns a lower value to the model for pollution potential as the depth to water increases. However, in karst areas, depth to water may not be a critical parameter to aquifer protection because the contaminants can enter the aquifer directly through solutional openings and fractures which intercept surface and shallow subsurface flow. As another example, in karst areas dilution may be the most significant attenuation mechanism, but this mechanism is ignored by the net recharge parameter.

As part of the study, each map produced was assigned a confidence level. The confidence level is based on the confidence in the information used to determine the DRASTIC Index. Most of the data necessary to produce a map of DRASTIC Indexes does not exist on the KNRIS. A vast amount of time and manpower was spent digitizing geologic maps, soil survey maps and water well information in order to use the Geographic Information System to produce the DRASTIC Index maps. The confidence level for the final DRASTIC maps ranged from 52 to 95 percent. The cost of mapping Kentucky using the DRASTIC Method is estimated at $2 million, and then the maps would only be suitable for a first-cut analysis, not actual permitting or response decisions. The final report, "DRASTIC Analysis for Application by State Government," concludes that the data currently available in Kentucky is marginally acceptable and difficult to access.

The DRASTIC Method is designed to adequately assess the vulnerability of granular aquifers, but many of the attenuation processes in the model are not active in karst areas.

Kentucky Pilot Wellhead Protection Study

Personnel from the University of Kentucky, Department of Geological Sciences, conducted a pilot wellhead protection project in Kentucky. The project was designed to identify and evaluate existing data sources and their utility in identifying potential sources of contamination. The objectives of the study were to: delineate wellhead protection areas for the cities of Georgetown, Elizabethtown, and Calvert City; to identify the potential sources of contamination within the wellhead protection areas; and to gain experience in the development and application of the Wellhead Protection Program in Kentucky.

A wellhead protection area was delineated for each of the three study areas. Two study areas were located in karst areas. The third study area was located in an alluvial aquifer. Hydrogeologic mapping was chosen as the wellhead delineation method in the karst study areas (Georgetown and Elizabethtown). These areas had been the subjects of earlier hydrogeologic studies that provided information about the recharge areas of the springs that provide the public water supplies. The third study area, Calvert City, relies on wells for public water supply. The wells are drilled into an alluvial aquifer. A pumping test was conducted to determine the hydrogeologic characteristics of the aquifer. Data from the pumping test was used to delineate the wellhead protection area.

Existing databases were used to identify and assemble information on the potential contamination sources that are located within the wellhead protection area. Many obstacles were encountered in identifying the potential contamination sources. Much of the data needed to identify the sources are stored in paper files. Locations for many of the facilities are referenced by street address, not a coordinate system. Sources referenced by street address require field inspection to be accurately plotted on maps. All information gathered during this study will be provided to the participating cities along with recommendations on additional work needed to satisfy the requirements of the Wellhead Protection Program.

North Marshall Water District Pilot Project

The Division of Water is conducting a wellhead protection pilot project in Marshall County. The goal of the project is to establish a comprehensive wellhead protection plan for the North Marshall Water District. This project will allow the state to further identify resource and data needs for implementing a state program. The project will also identify the mechanisms needed to facilitate cooperation on both state and local levels.

It is expected that experiences gained by the state during this project will be used to further develop and implement the Kentucky Wellhead Protection Program. The division of program responsibilities between state and local entities will be better and perhaps more equitably accomplished by basing it on real world experiences as opposed to abstract suppositions and assumptions.

Groundwater Issues

Information Systems

Protection of groundwater resources in Kentucky is impeded by a disjointed environmental information system that is typified as containing more gaps than data. A comprehensive groundwater protection program requires more than just data on groundwater and aquifers, but also requires information on the existing threats to groundwater. State regulatory agencies do not always collect all of the necessary data or it is collected in a cumbersome format that does not lend itself to easy data retrieval and/or transfer.

Projects conducted in the last biennium have identified the need to plan and coordinate data collection and the need to improve the transfer of data between agencies. There are state programs that collect facility information, but do not require latitude and longitude location information. Street addresses are typically collected, but are useless to the state's Geographic Information System. In order for Kentucky to develop a useful Geographic Information System, location data must include latitude and longitude coordinates. When a program requires information from a regulated community, consideration should be given as to how other agencies might use the data for regulatory programs, investigative studies, and pollution control.

The Division of Water could employ computer methods to assist in mapping and characterizing the State's aquifers, but the existing Geographic Information System is too broad in scope and the data available is too general and contains too many gaps. Very few areas of the state have adequate coverage and the geologic and/or hydrogeologic information necessary to map and characterize aquifers has not been entered into the system.

Kentucky needs to follow the federal lead in adopting a minimum set of data requirements that would be collected by all regulatory programs. Establishing minimum data requirements for all programs would have the effect of giving all databases a set of common elements and would facilitate the transfer of data between programs. Establishing a standard set of minimum data elements could also help to eliminate some of the existing gaps in the data.

Contamination of Public Water Supplies

One of the most direct ways for environmental contamination to affect public health is through drinking water supplies. In 1988, the Division of Water initiated a three-year program aimed at testing all public water supplies for volatile synthetic organic chemical contamination. In 1989, approximately 140 of the water supplies tested relied on groundwater. Approximately 12 percent of the groundwater supplies tested in 1989 had some level of contamination during at least one of the quarterly testing events. The contaminant detected most often was 1, 4-dichlorobenzene, followed by 1,1,1-trichloroethane.

Over the past year the Division of Water has investigated several situations where groundwater contamination has impacted a public water supply. The Holiday Mobile Home Park Public Water Supply in Dayhoit was decommissioned in 1989 because of chemical contamination detected as part of the Volatile Synthetic Organic Chemical Monitoring Program. The source of the contamination was determined to be improper waste disposal from previous industrial activity in the vicinity. The extent of the contamination has not yet been determined. The hydrogeology of the Dayhoit area is very complex and several separate water bearing zones may have been interconnected by poorly constructed water wells, complicating the task of delineating the possible migration pathways of the contamination.

The Georgetown Municipal Water and Sewer Service in Georgetown temporarily discontinued the use of Royal Spring in the Fall of 1989 because of benzene contamination. In contrast to the situation at Dayhoit, the extent of the contamination is fairly well known. Samples taken from wells penetrating various portions of the aquifer indicate that only a small part of the groundwater basin that supplies Royal Spring has been affected, but attempts to locate the contaminant's source have been unsuccessful as of this date.

These problems indicate a need for a more effective groundwater protection program and a more unified approach to groundwater protection. More emphasis needs to be placed on preventing groundwater contamination instead of remediating problems after they occur. More work needs to be done to characterize the state's groundwater resources and to insure their protection.

Uncertified Drillers

During 1989, nearly 20 percent of Kentucky's certified drillers allowed their certification to expire. Many of those drillers may still be drilling water wells. Resource limitations have prevented an effective enforcement program resulting in an increasing number of uncertified drillers. The Division of Water is concerned that an ineffective program to certify and regulate water well drillers will result in improperly constructed water wells that provide a direct route for contaminants to enter an aquifer. A proliferation of improperly constructed water wells may result in a greater frequency and magnitude of groundwater contamination incidents.

In addition, the Division only certifies the drillers of water supply wells. Standards for the construction of water supply wells in Kentucky have been in effect since 1986. In contrast, drillers that install environmental monitoring wells are unregulated. No uniform set of standards exists for the construction of monitoring wells. The Division of Water is concerned that improperly constructed monitoring wells could be contributing to groundwater contamination. The certification and education of water well drillers should be expanded to include monitoring well drillers and a set of construction standards for monitoring wells should be established. A more active enforcement and inspection program would help ensure that all wells are acceptably constructed to protect groundwater supplies and public health.

Resource Management

In 1988, Kentucky experienced a major drought. The drought and subsequent water shortages demonstrated the need for Kentucky to better manage its water resources. Water well drilling activity increased across Kentucky in an attempt to secure dependable water supplies to supplement or replace the waning surface supply. Approximately twenty of Kentucky's public water supplies that rely on groundwater implemented some type of conservation program to insure an adequate supply of water for their customers.

During the drought, groundwater was the major contributor to stream flow. Surface water supplies were greatly diminished, forcing many of the state's surface water users to implement conservation measures. The contribution that groundwater was making to stream flow was crucial in sustaining the water supply for a large portion of the state's population. Kentucky's dependence on groundwater points out a need to identify and characterize the available groundwater resource throughout the state. The geology of Kentucky lends itself to aquifers that have a very local areal extent. The hydrostratigraphy of the state does not generally support large regional aquifers. One way to accomplish the task of identifying and characterizing the groundwater resource is through a comprehensive aquifer mapping and groundwater classification program. A better understanding of the resource would aid groundwater protection programs and make the groundwater withdrawal permitting program more efficient. A comprehensive aquifer mapping and characterization program would help to ensure that available groundwater resources are properly evaluated and allocated.

Quality considerations are also of great importance in managing the resource. The natural quality of the groundwaters of many of the state's aquifers has not been adequately characterized. Kentucky needs to implement a comprehensive program to assess groundwater quality. The natural groundwater quality of the aquifers must be known in order to make aquifer classification decisions and to manage the resource for its highest and best use.

Of considerable concern is the continued practice of discharging pollutants to groundwater. The KPDES program permits wastewater discharges directly to groundwater. If this practice is to continue, effective effluent limits must be strictly maintained and enforced. Kentucky needs an aquifer protection program that will ensure that discharges to groundwater do not adversely impact the state's aquifers. Kentucky needs to implement new programs that will protect existing groundwater quality and, at the same time, step-up the enforcement of existing programs that protect groundwater quality.

Nonpoint Source Groundwater Contamination

Agriculture, mining and mineral extraction, and urban-residential development are the primary land uses in Kentucky. Many activities associated with these land uses are known to generate a great number of contaminants which have significant potential to degrade groundwater resources and adversely impact groundwater-supported drinking water supplies. However, the threat that nonpoint source contamination poses to the state's aquifers is difficult to assess because of a lack of sufficient data. At this time, few detailed studies of nonpoint pollution of groundwater in Kentucky have been conducted. There is a critical need to conduct surveys to identify particular nonpoint contaminants of greatest concern, to map areas of degraded or otherwise adversely impacted groundwater, and to investigate the migration and fate of nonpoint contaminants in the various groundwater regimes. The lack of this information greatly hinders the development of effective control and remediation measures, and impedes the establishment of an appropriate groundwater protection regulatory program for nonpoint source contamination.

Three major classes of nonpoint source pollutants are believed to be contributing to significant and potentially widespread groundwater contamination. These pollutants are: agrichemicals, especially pesticides and herbicides; chlorides and other brine constituents generated as a result of oil and gas exploration and extraction; and effluent from septic tanks, seepage pits, and other groundwater discharges.

Kentucky is principally an agricultural state. Approximately 75 percent of the state consists of karst topography, and much of this area contains extensive, heavily-cropped farmland. Although the soils are generally thick and retentive, agrichemicals such as pesticides and fertilizers applied in these areas can directly enter the groundwater system through solutional openings and fractures in the soluble carbonate bedrock.

In most of Eastern Kentucky, and in large portions of the central and western parts of the state, extensive oil and gas exploration and extraction have occurred historically and are continuing today. It is estimated that thousands of abandoned, unplugged or improperly plugged wells and exploration boreholes exist in these areas. These wells and boreholes allow cross contamination of aquifers with briny fluids, hydrocarbons, and soil waters. Other related sources of this type of nonpoint contamination include injection wells which dispose of oil field brines; secondary oil recovery techniques, particularly water-flooding and steam injection; and gas field pressurization. All of these sources can contribute to the migration of brines and hydrocarbons into aquifers supplying private and public drinking water.

Septic tank systems are the most common form of sewage treatment in rural, and in many urban, residential areas. The Cabinet for Human Resources (CHR) has estimated that 60-70 percent of Kentucky homesites are not sewered. Improperly sited or inadequately constructed septic systems may contribute nitrates, bacteria, viruses, disposed hazardous chemicals, and other pollutants to the local groundwater regime.

Concerns about the sources of nonpoint groundwater contamination, the degree and extent of impact, and the potential threat posed to the aquifers of the state are best addressed by basic research. Adequate funding necessary to support relevant scientific investigations by academic and state regulatory agencies should be provided. A comprehensive aquifer mapping and groundwater classification program is needed in order to identify groundwater resources which may be particularly vulnerable to nonpoint pollution. This program should include assessments of groundwater quality in order to identify particular contaminants of concern, evaluate existing levels of contamination, and monitor impacts of contamination on aquifers and groundwater-supported drinking water supplies throughout the state. In addition, Kentucky would benefit greatly from a comprehensive aquifer protection program which assures that important groundwater resources are not degraded or adversely impacted by nonpoint source contamination.

Federal Policy Responsibility

The U.S. Environmental Protection Agency must develop a concept for groundwater protection that will be implemented through development of a federal regulatory scenario including minimum groundwater quality standards and mandatory requirements for state programs. Additionally, EPA must integrate this overall groundwater protection strategy into the regulations promulgated under the authority of the Clean Water Act, the Toxic Substances Control Act, the Comprehensive Environmental Response, Compensation and Liability Act, the Safe Drinking Water Act, and the Federal Insecticides, Fungicide and Rodenticide Act. EPA, not states, must take the lead in a comprehensive framework for coordinating federal programs. Since they establish minimum standards for programs that may be delegated to states and promulgate regulations for those programs that are not delegated, only EPA can ensure coordination of all programs that impact groundwater.

EPA should promulgate regulations for all of the above laws to ensure consistency in groundwater quality standards and protection measures. The states could then promulgate regulations that would ensure protection of unique, sensitive, or vulnerable areas within the state. Establishment of regulatory standards at the federal level also addresses concerns for aquifers that cross state boundaries.